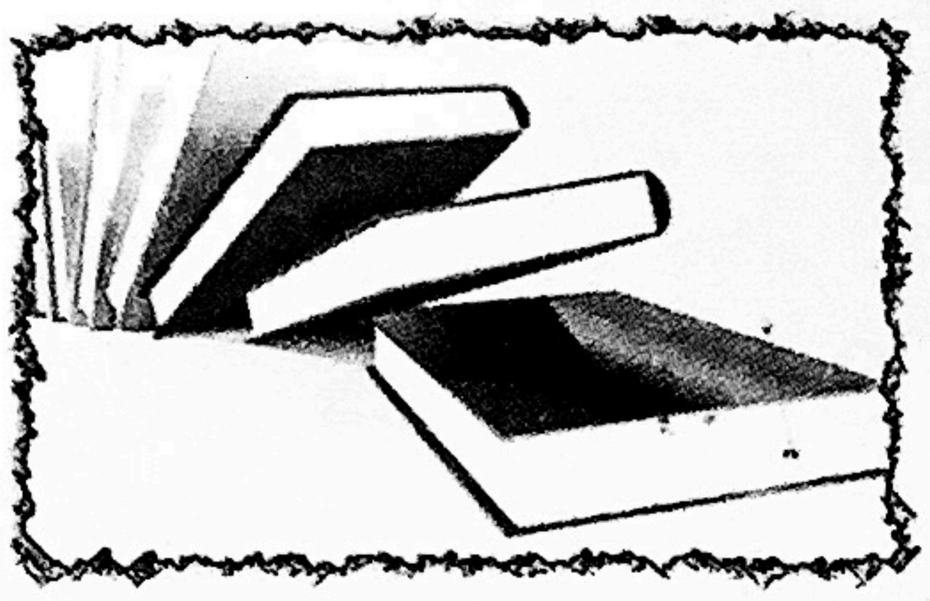
INDEX



Name DEBADATTA THAKUR

Class B.Tech Section EEE Roll No. 81 Year MO/23

Subject PS LAB (FRIDAY)

Sl. No.	Experiment Description	Experiment Date	Submission Date	Remarks Signature
1.	Ferro-Resonance characteristics.	11/08	18/08	25/8/23
2.	Negative Sequence Reactance.	18/08	25/08	01/09/23
3.	Over-Current Relay Charecteristics.	25/08	1/09	
4.	Parallel Operations of AC Alternators.	1/9	8/9	08/09/23
5.	Transformer Oil Breakdown Test.	8/9	15/9	6/10/23
6.	Power Factor Control (L-load).	6/10	13/10	13/10/23
7.	IDMT & DMT OC Relay charecteristics (OC Relay).	6/10	13/10	13/10/23

Sl. No.	Experiment Description	Experiment Date	Submission Date	Remarks Signature
8.	Measurement of ABCD constants of transmission line.	13/10	3/11	Sajalwal 3/11/23
9.	Transformer protection using differential relay.	3/11	7/11	

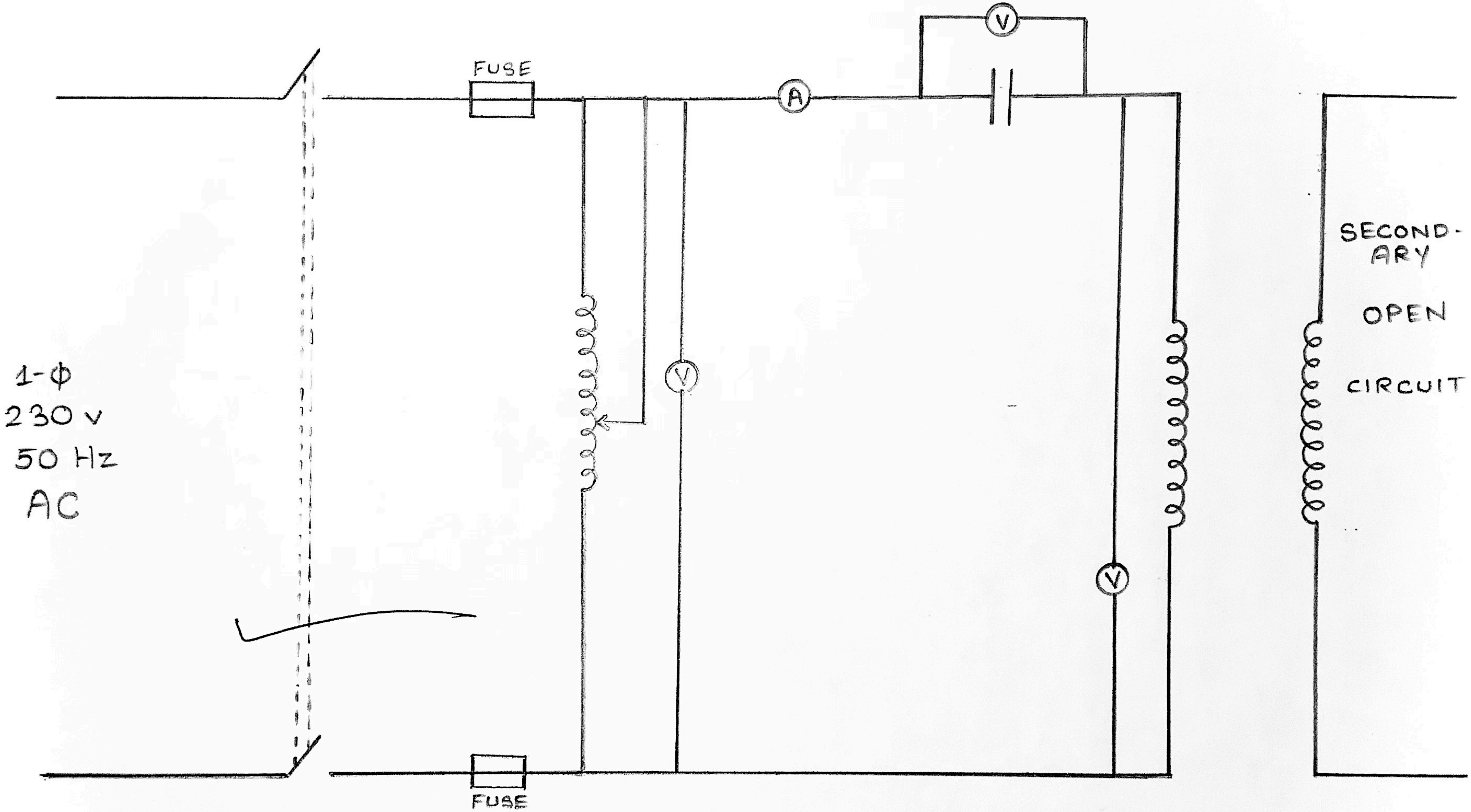


FIG 1·1

(CIRCUIT DIAGRAM)

Experiment - 1

AIM - Obtain Ferro-Resonance charecteristics of a 1-ϕ transformer at no-load.

APPARATUS -

Capacitor (20 μF), 1 nos.
1-ϕ Variac (230 V, 3 KVA), 1 nos.
1-ϕ Transformer (220/110 V), 1 nos.
AC Voltmeter (0-600 V), 1 nos.
AC Voltmeter (0-300 V), 1 nos.
AC Ammeter (0-10 A), 1 nos.

THEORY -

Partial resonance condition occours in power system when unbalanced configuration occours so as to place capacitances in series with inductances. When a transformer is connected to a long transmission line and both are switched together, such a condition might occour.

The ferro-resonance occours in a ferromagnetic material like the iron. If in a power system a cable is connected to a

(CONDITIONS LEADING TO FERRO-RESONANCE)

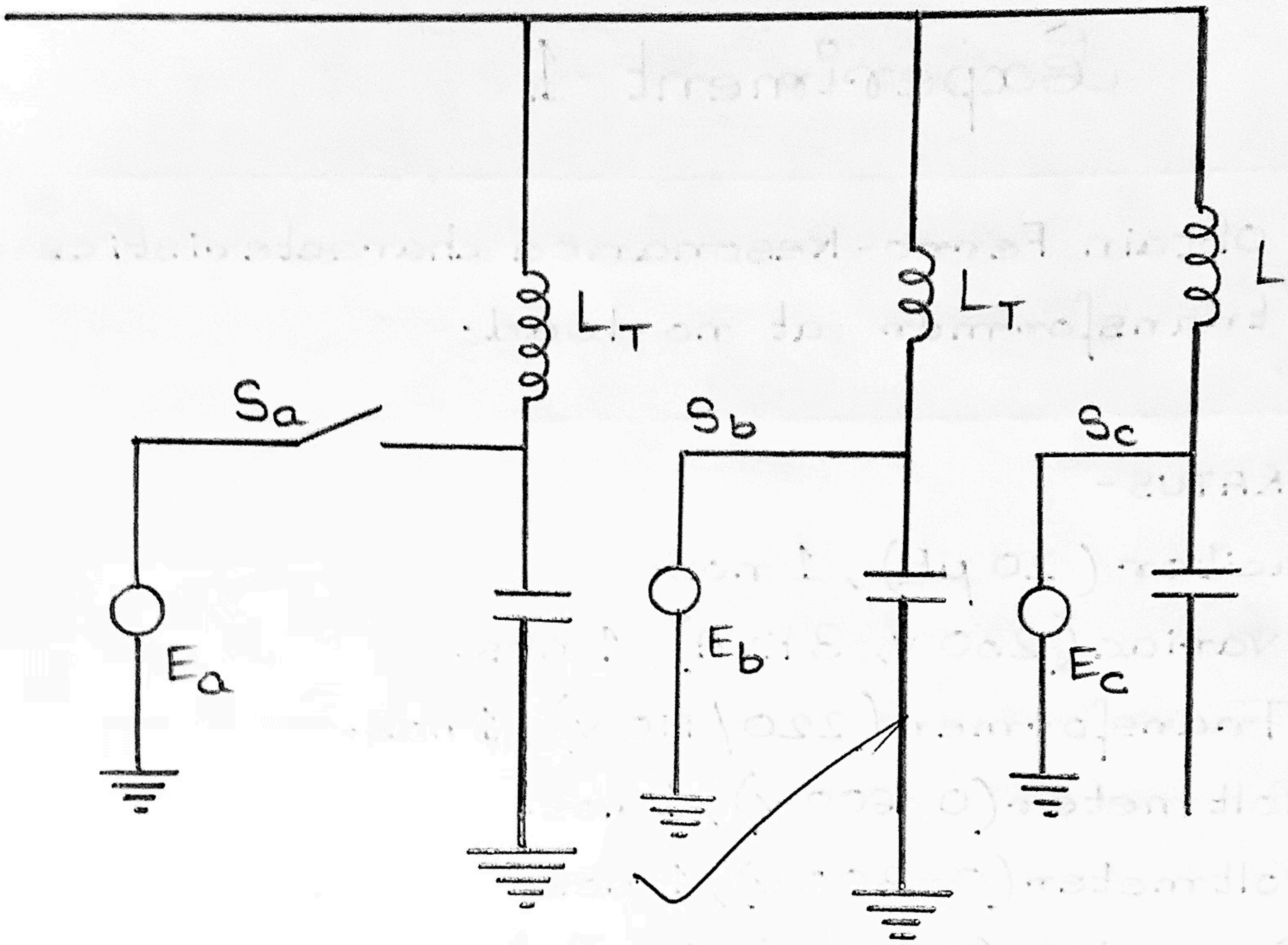


FIG 1.2

(Generator connected to transformer)

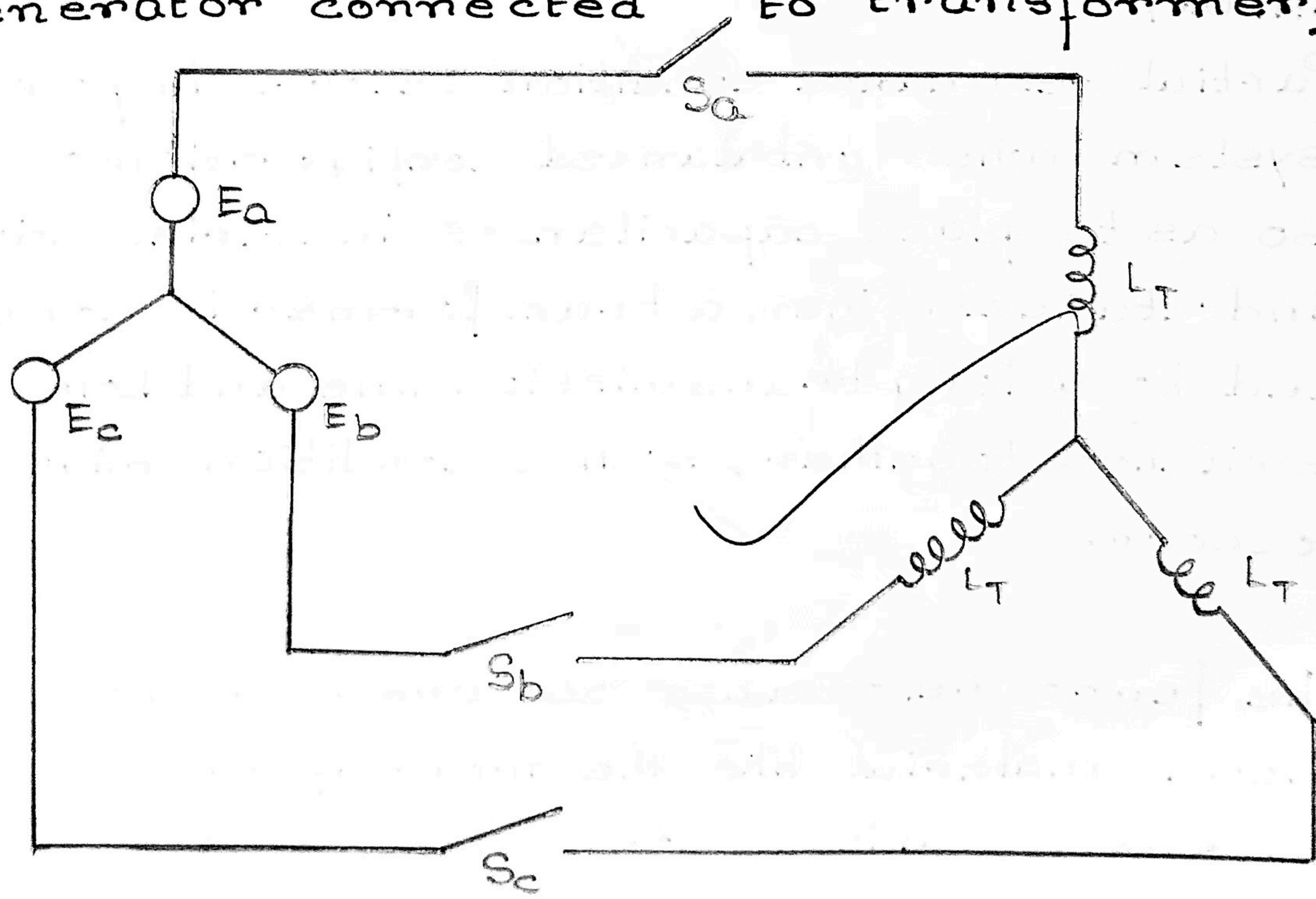


FIG 1.3

transf [illegible] ircuit where transformer winding acts as an inductor, the cable capacitance form capacitor of the LC circuit.

PROCEDURE-

Give AC voltage slowely via 1-ϕ variac. At one position there will be a sudden jump in voltage accross capacitor & inductor. Now decrease voltage to zero supply and again there is a sudden fall in voltage. Plot V_1 (supply voltage) and V_3 (transformer voltage).

OBSERVATION TABLE-

SL.	V_1	V_2	V_3	A (amps)
1.	100	20	60	0.9
2.	140	20	85	1
3.	160	30	100	1.2
4.	177	250	170	4.5
5.	160	245	168	4.2
6.	140	230	163	4
7.	100	210	162	3.5
8.	60	15	40	1
9.	6	8	0.5	0.3

Teacher's Signature [illegible] 25/8/23

Experiment-2

AIM- Determination of negative sequence reactance of a 3-ϕ alternator.

APPARATUS-

1-ϕ Auto-Transformer (230 V, 3 KVA), 1 nos.
Rheostat (200 Ω, 2·8 A), 1 nos.
AC Voltmeter (0-600 V), 1 nos.
AC Ammeter (0-10 A), 1 nos.
AC Wattmeter (600 V), 1 nos.

THEORY-

When a synchronous generator is carrying an unbalanced load, its operation may be analysed by symmetrical components. In a synchronous machine the positive sequence current produces an armature reaction which is stationary with respect to the field poles.

The negative sequence is produced by an

CIRCUIT DIAGRAM

armature reaction which rotates around armature at synchronous speed in the direction to that of field poles at synchronous speed. Inducing current in the field damper winding and rotor iron. The impedance encountered by the -ve sequence is the -ve sequence impedance of the generator.

MATHEMATICAL FORMULAS -

$$V/I = Z_{eq} = 3/2\ Z \quad \therefore Z_{eq} = V/I$$

$$W = I^2 R_{eq} = I^2 \frac{3}{2} R \quad \therefore R_{eq} = W/I^2$$

$$X = \sqrt{Z^2 - R^2}$$

$$R = W\ \cancel{\text{per}}\ \text{phase} / I_{sc}^2 \quad \therefore R = \frac{2}{3} R_{eq}$$

$$Z = 2V/3I \quad \therefore Z = \frac{2}{3} Z_{eq}$$

PROCEDURE-

a. Make connections and run DC motor at the synchronous speed while keeping the short circuit current low.

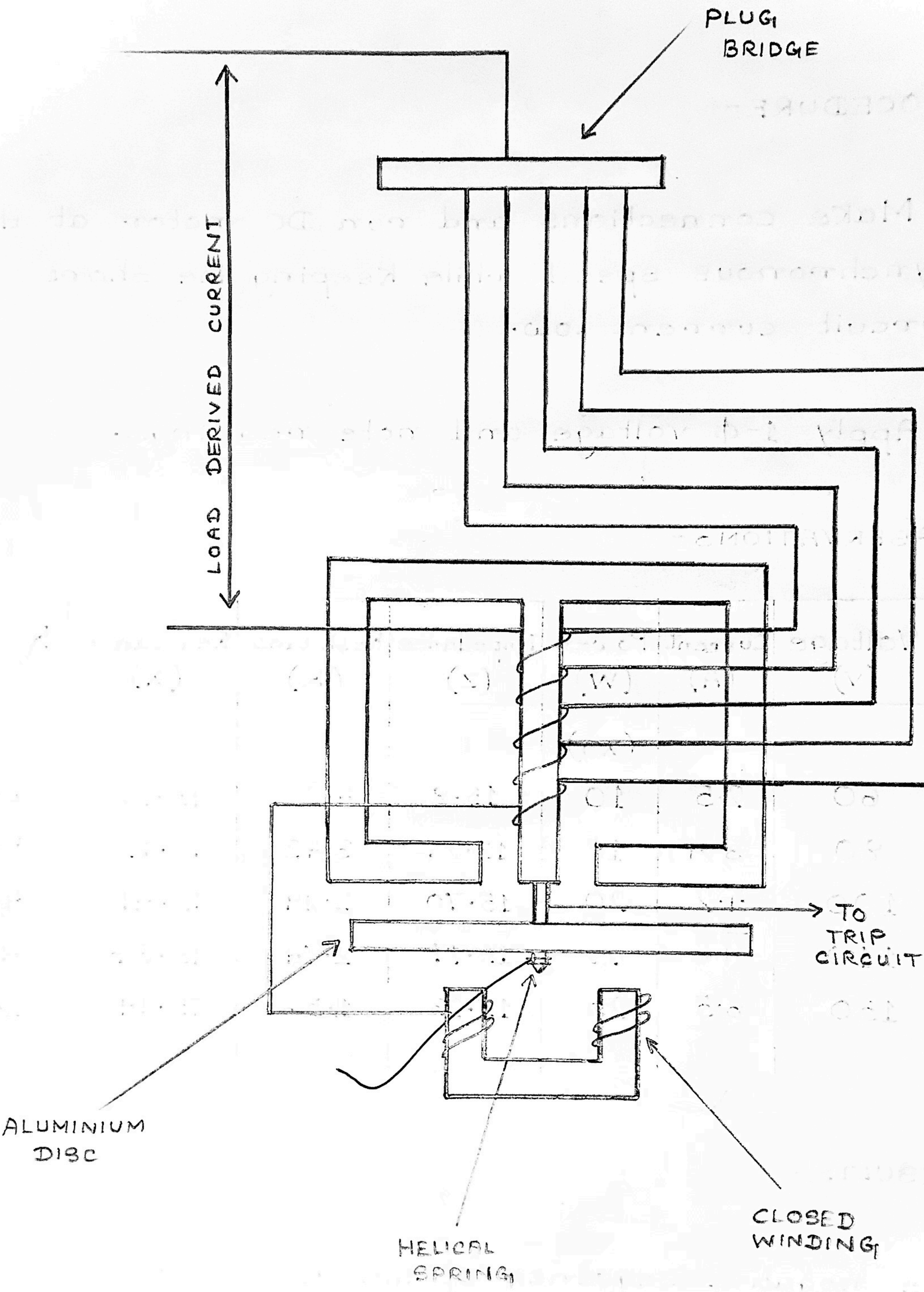
b. Apply 1-Φ voltage and note readings.

OBSERVATIONS-

SL.	Voltage (V)	Current (A)	Power (W)	Impedance (Z)	Resistance (R)	Reactance (X)	Req
			(x4)				
1.	60	2.5	10	15.8	4.22	15.26	6.40
2.	80	3.4	15	15.57	3.42	15.12	5.19
3.	100	4.2	20	15.70	2.99	15.41	4.53
4.	110	4.6	22	15.77	2.74	15.53	4.15
5.	150	6.5	25	15.23	1.56	15.14	2.36

RESULTS-

The negative sequence of the alternator is found and it is $X = 15.292\ \Omega$



—OVER-CURRENT Relay

Experiment-3

AIM - Determination of over-current relay characteristics using relay test setup.

APPARATUS -

Over-Current Relay
Relay Test Setup

THEORY -

A protective relay is a device which detects the fault and initiates the operation of the circuit breaker to isolate the defective element from the healthy circuit.

Instantaneous over-current Relay - No time delay is provided for the operation.

Inverse Time over-current Relay - Operating time reduces as the actuating quantity increase in magnitude.

Inverse definite minimum time relay - Operating Time is inversely proportional to the fault current.

Very Inverse Relay - Saturation of core occours at a later stage.

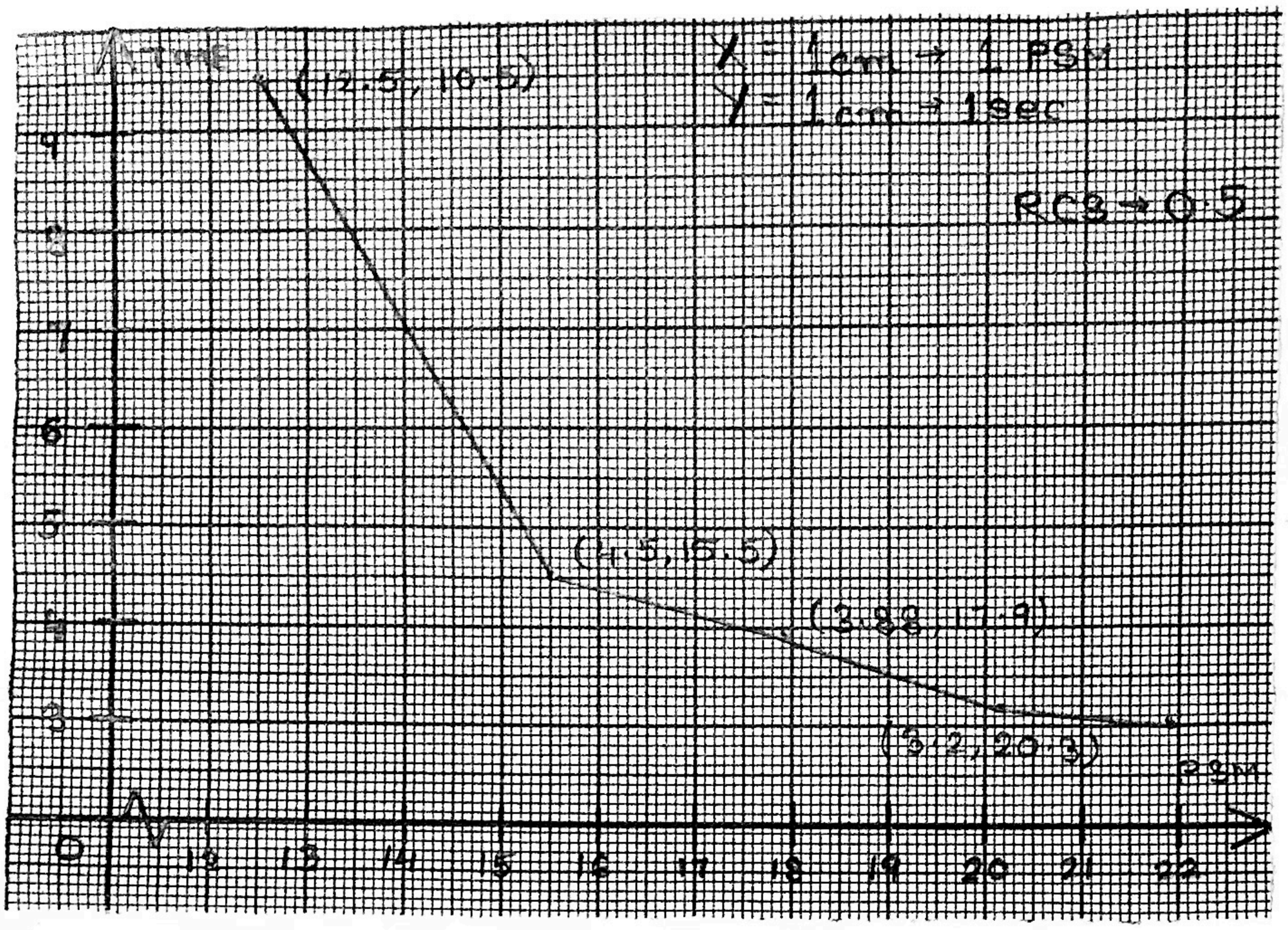
FORMULAE -

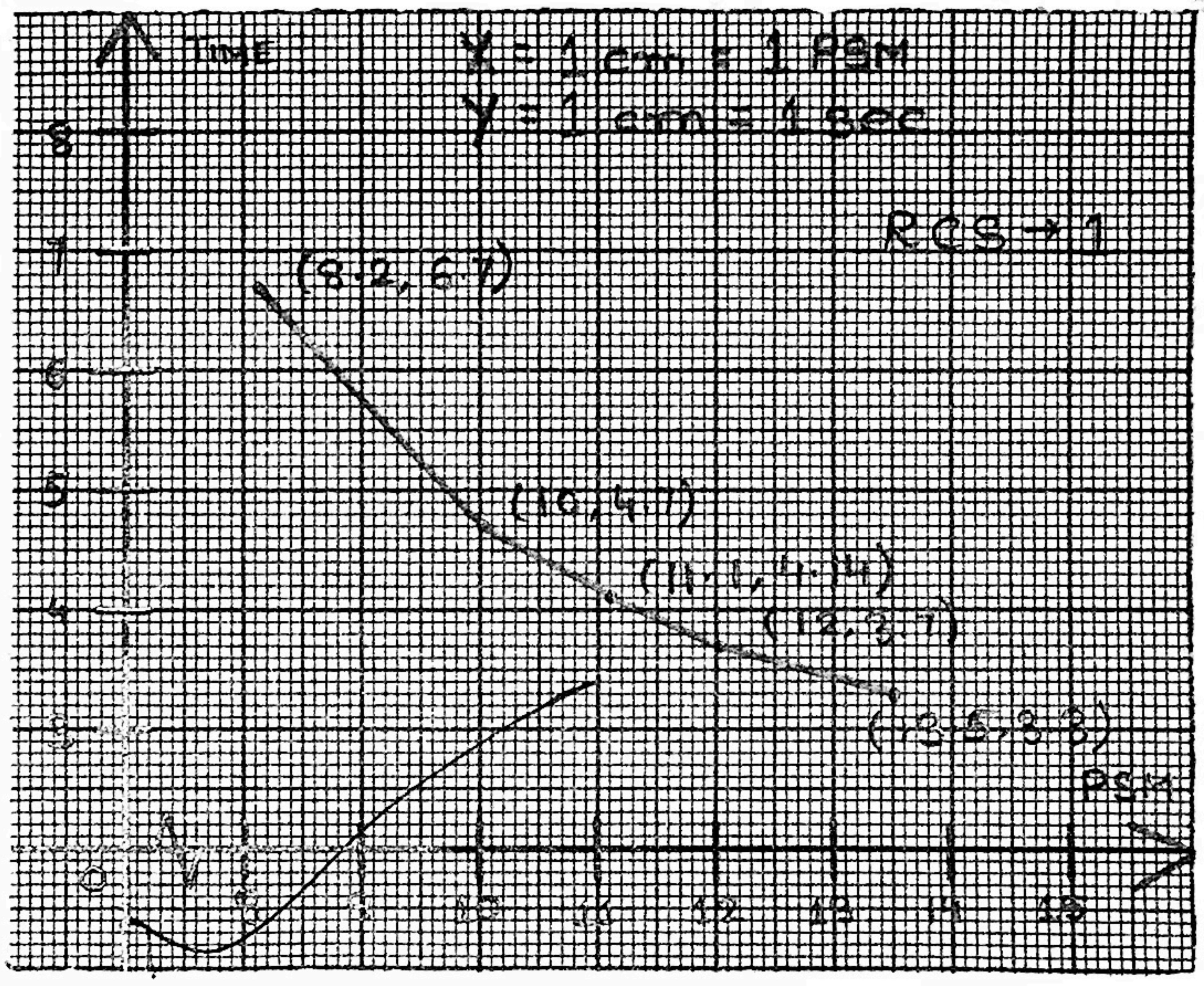
PSM = Primary Fault Current / Relay current Settings x Current Transformer Ratio

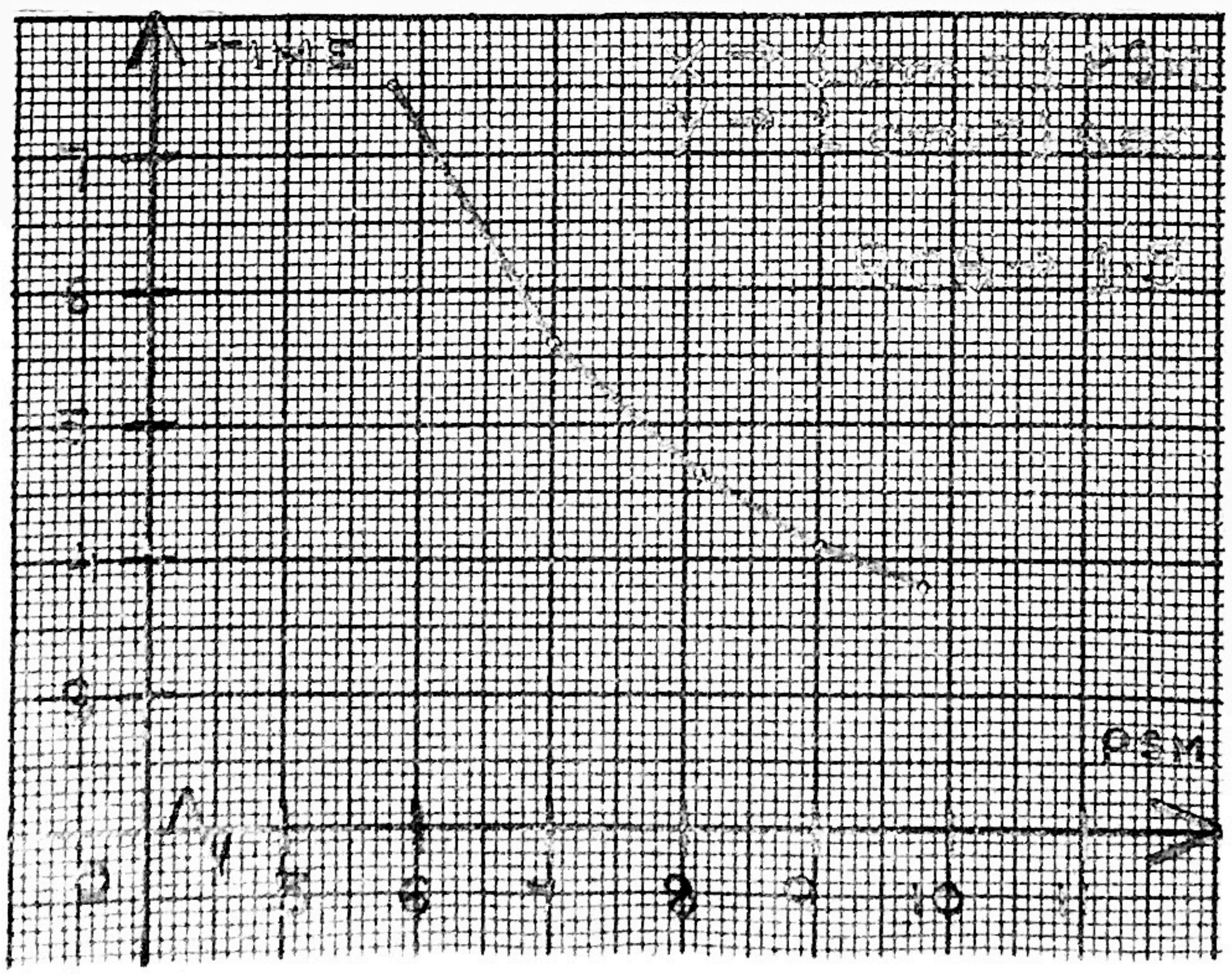
OBSERVATIONS -

SL.	TIME	A%.	A	P.S.M.
1.	10.5	25.2	6.26	12.52
2.	4.5	55.0	7.75	15.50
3.	3.88	79.2	8.96	17.92
4.	3.27	103.6	10.18	20.36
5.	3.01	118.1	10.90	21.80

Relay Current Setting → 0.5
Ratio → 1


TIME
(12.5, 10.5)
X = 1cm → 1 PSM
Y = 1cm → 1sec
RCS → 0.5
(4.5, 15.5)
(3.88, 17.9)
(3.2, 20.3)
PSM


TIME
X = 1 cm = 1 PSM
Y = 1 cm = 1 sec
RCS → 1
(8.2, 6.7)
(10, 4.7)
(11.1, 4.14)
(12, 3.7)
(13.5, 3.3)
PSM


TIME
PSM

Expt. No.

SL.	TIME	A%.	A	P.S.M.
1.	6.73	65.1	8.25	8.25
2.	4.76	101	10.05	10.05
3.	4.14	123.2	11.16	11.16
4.	3.79	140.6	12.03	12.03
5.	3.36	170.1	13.50	13.50

Relay Current Setting → 1
Ratio → 1

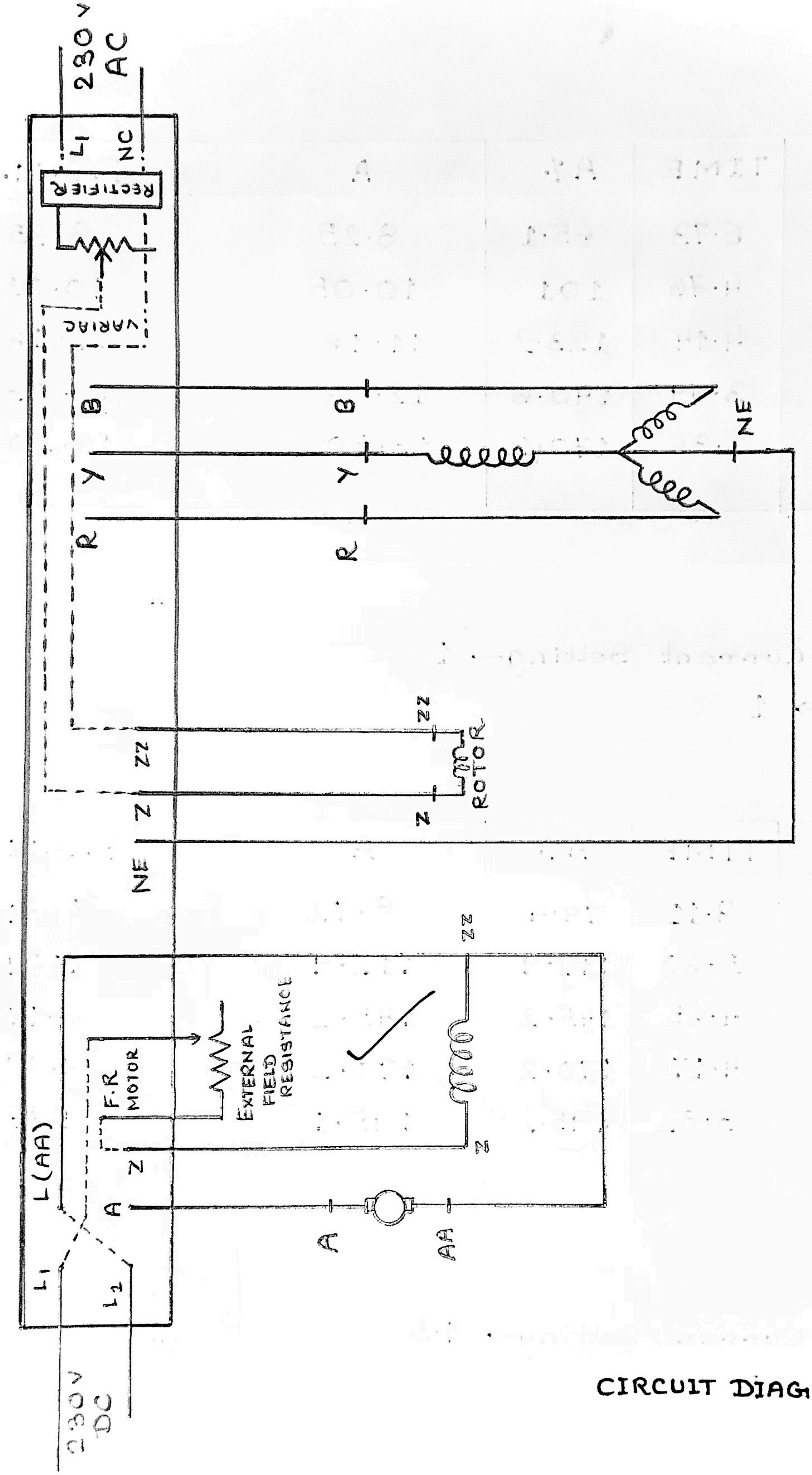
SL.	TIME	A%.	A	P.S.M.
1.	8.11	74.4	8.72	5.81
2.	5.60	112.9	112.9	7.09
3.	4.65	145.2	145.2	8.17
4.	4.17	170.2	170.2	9.00
5.	3.82	195.2	195.1	9.83

OXFORD

Relay Current Setting → 1.5
Ratio → 1

01/09/23

Teacher's Signature ....



CIRCUIT DIAGRAM-1

Experiment - 4

AIM - Study of sychronizing panel for parallel operation of AC generator.

APPARATUS - Synchronizing panel

THEORY -

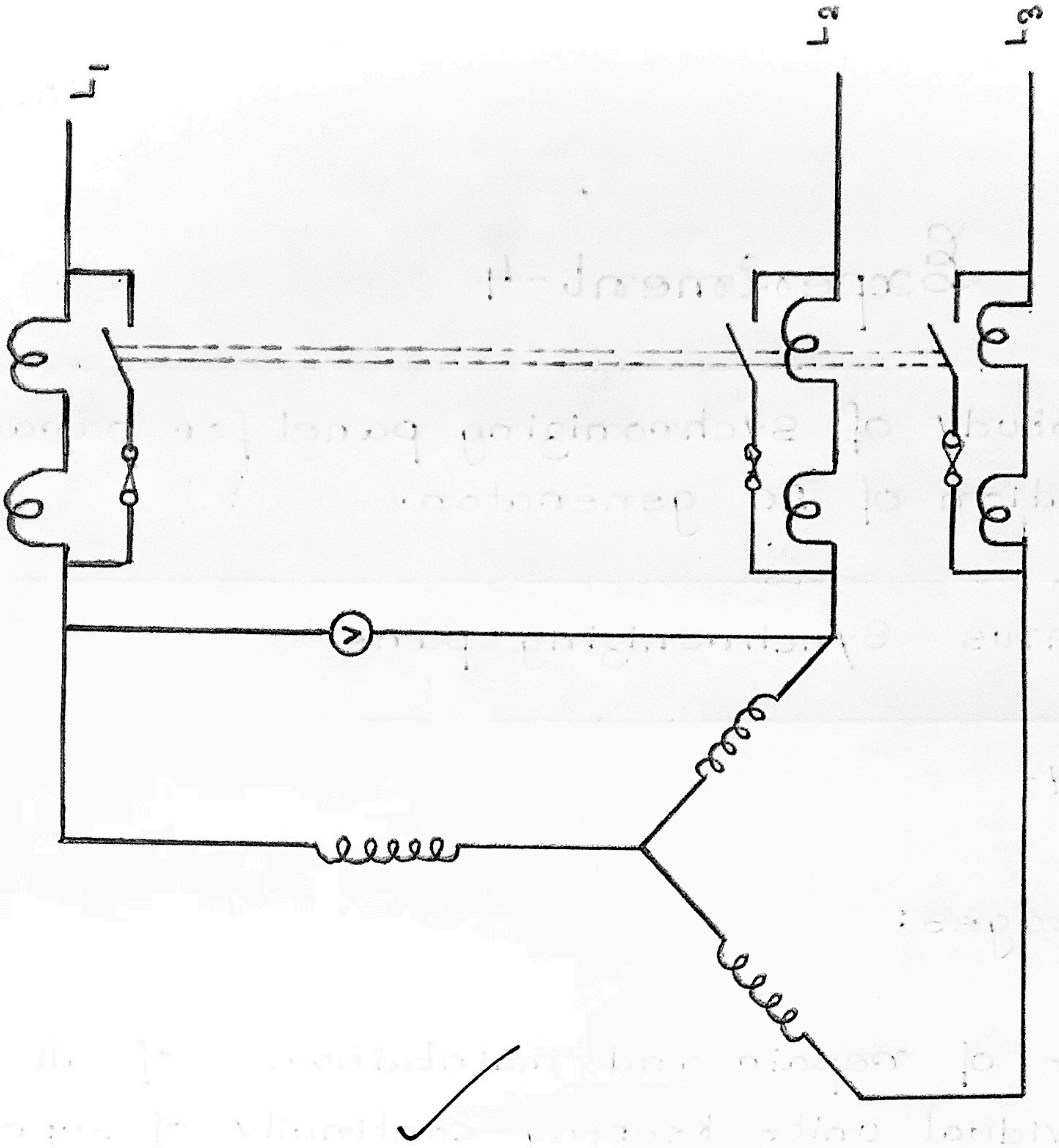
Advantages:

a. Ease of repair and maintainance of all the individual units keeping continuity of supply.

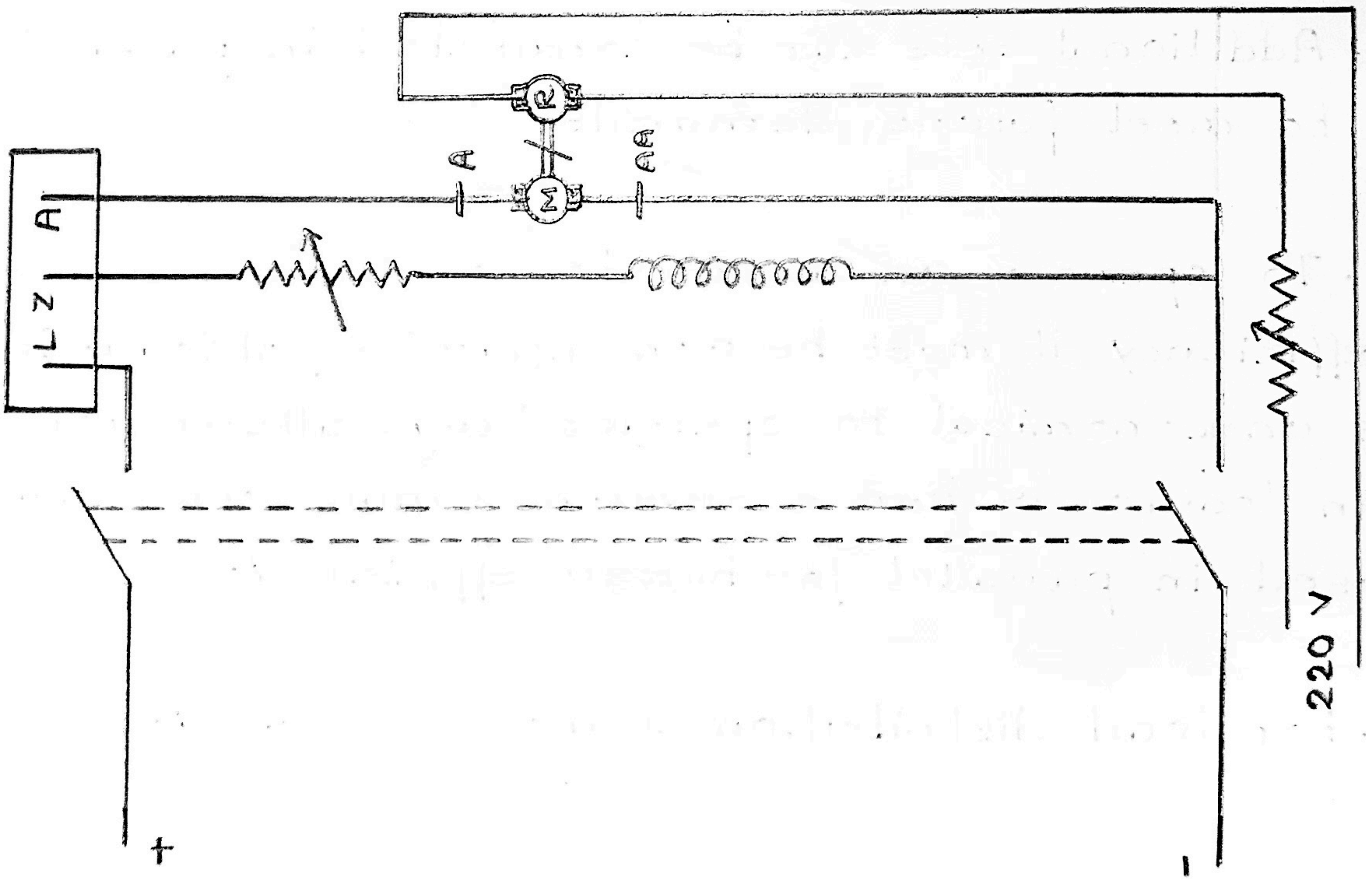
b. Additional sets can be connected in parallel to meet future demands.

c. To operate ~~an~~ alternator on maximum efficiency it must be run near its full load. It is uneconomical to operate large alternators on low loads hence several small units are used in parallel for better efficiency.

d. For load distribution & more reliability.



CIRCUIT DIAGRAM-2



Conditions:

a. The generated voltage of the incoming alternator to be connected in parallel with a bus-bar should be equal to bus bar voltage.

b. Frequency of generated voltage of incoming alternator should be equal to bus-bar frequency.

c. Phase sequence must be same.

d. Phase difference must be same.

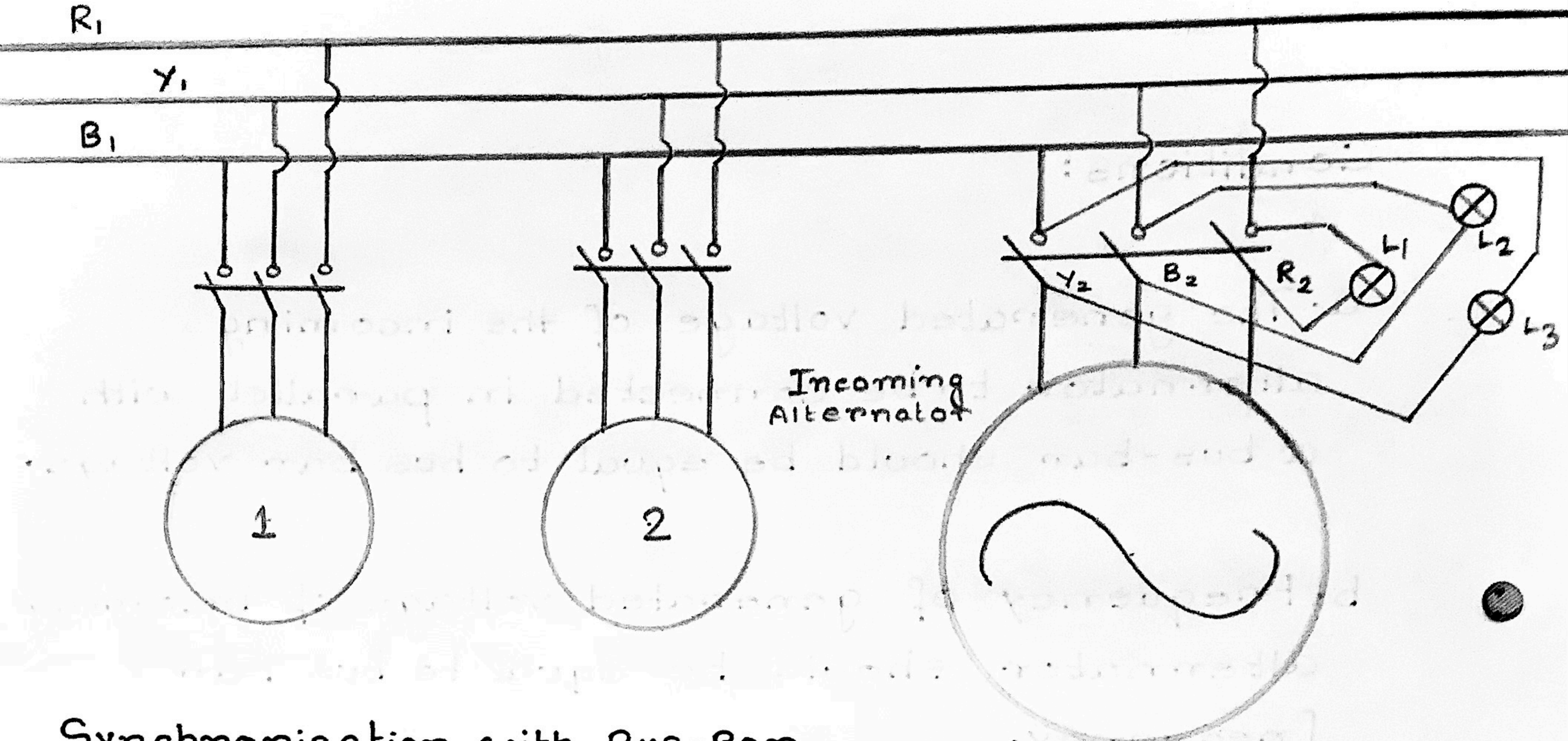
Methods :

a. Using THREE Lamps ✓

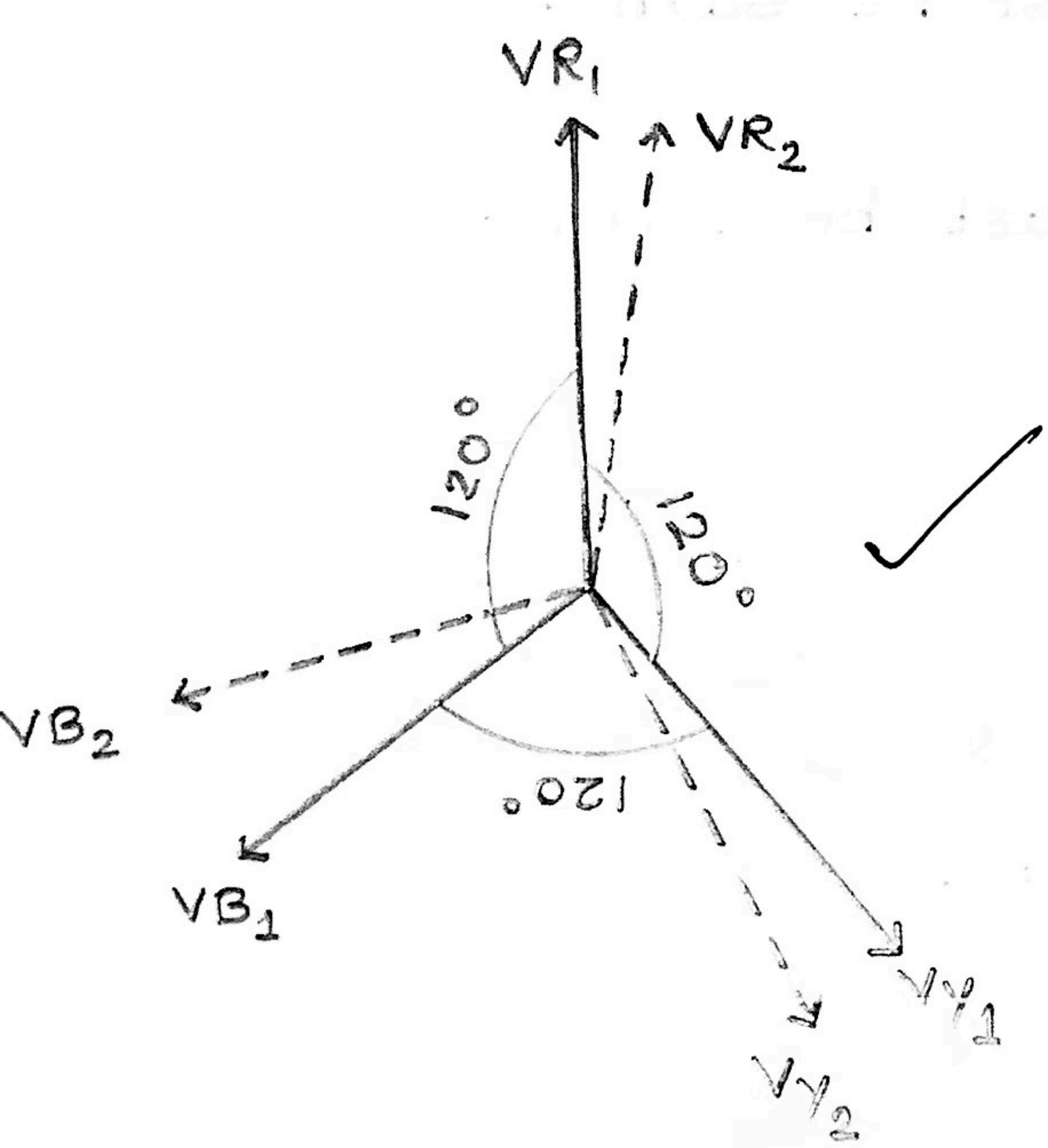
b. Using a synchroscope

PROCEDURE :

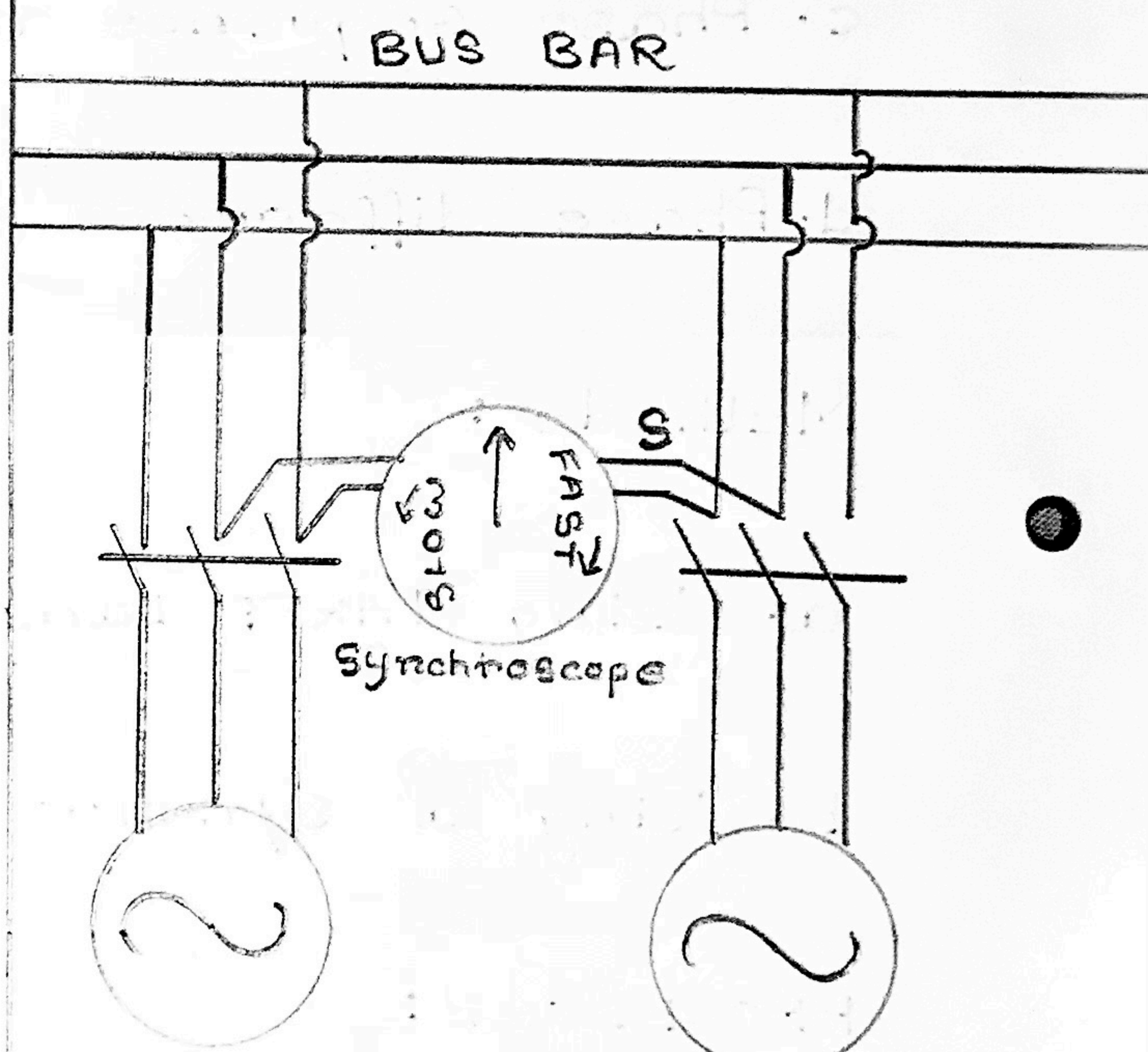
Make connections and ensure that the synchronising switch is open, external resistance in field circuit of motor is zero and



Synchronization with Bus-Bar



Same phase Sequence



Synchroscope Synchronization

of the alternator is maximum. Switch on DC motor-1 and 2 using starter. Adjust their speed to rated speed of alternator. Switch on DC supply to field of alternator. Look out the synchronoscope and when it is exactly in middle close switch and once synchronized switch off synchronizing switch, bus-bar switch, DC mains & motor and alternator.

PRECAUTIONS-

a. Always switch ON DC motor after ensuring it is loaded only, the AC generator.

b. MCB for synchroscope should be OFF.

c. MCB for DC Excitor must be in OFF.

RESULT-

AC generators were successfully synchronized using the synchronizing panel.

Tejaswal
08/09/23

SL.	kV(2.5m)
1.	17
2.	27
3.	29
4.	24
5.	23
6.	29
7.	37
8.	31
9.	30

Breakdown Voltages
for 2.5 mm gap

SL.	KV(2mm)
1.	35
2.	28
3.	35
4.	30
5.	33
6.	34

Breakdown Voltages
for 2mm gap

Experiment - 5

AIM - Determining breakdown voltage of the transformer oil using kit.

APPARATUS - Transformer oil test kit.

THEORY - The set is admirably suited for testing the dielectric strength of insulating oils. Samples are taken and the gap is adjusted and locked. It works on the same principle as high voltage test. A gap of 2 mm & 2.5 mm are tested. The must be filled to within a centimeter of the brim.

PROCEDURE -

a. Adjust gap between electrodes to 2 mm or 2.5 mm
b. Fill the cup with oil and place on HT electrodes.
c. Switch 'ON' main supply and lamp glows.
d. Switch lower to bring it to zero position.
e. Push raise and switch 'ON', note readings.

RESULTS -

The oil breakdown voltages were observed for 2 mm & 2.5 mm gap in electrodes.

CIRCUIT DIAGRAM FOR E/5

TECHNICAL SPECIFICATIONS:

Input : 230 v , 1-ϕ , 50 Hz AC
Output : 0-60 kV
Capacity : 1 KVA

CONSTRUCTION :

All the components are involved in the compact & rugged device and are mounted on front VHT transformer. It is epoxy resist cast on which HT output terminals are provided on top plate. These HT electrodes are shaped suitably to accomodate the setup.

PRECAUTIONS :

a. The top lid must be pressed for setup to work.
b. Transformer Oil must not be filled to the brim
c. Sudden high voltage must not be applied.

Tejaleval
6/10/22

Experiment - 6

AIM - Power Factor control of an inductive load using power factor connection kit.

APPARATUS -

Power Factor Correction Kit (1 no.)

Resistive Load (1 no.)

Connecting Wires

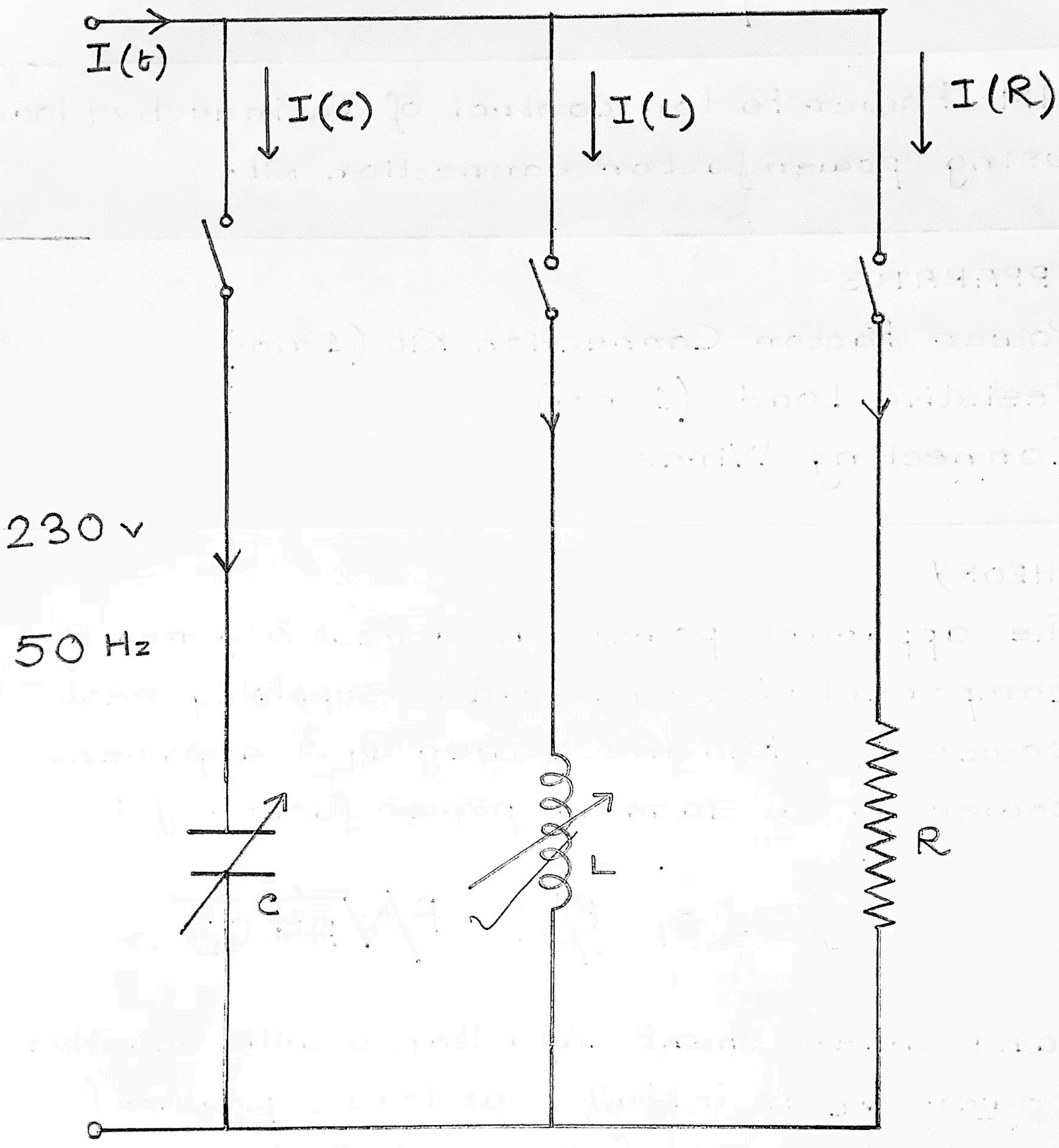
THEORY -

The apparant power has a real & a reactive component. Assume load is supplying real power P_1, Reactive power Q_1 & apparent power S_1 at lagging power factor of :

$$\cos \theta_1 = P/S_1 = P/\sqrt{P^2 + Q_1^2}$$

and when shunt capacitance with reactive power Q_c is installed at load, power factor can be improved from $\cos \theta_1$ to $\cos \theta_2$.

$$\cos \theta_2 = P/S_2 = P/\sqrt{P^2 + (Q_1^2 - Q_2^2)}$$



CIRCUIT DIAGRAM FOR E/6

PROCEDURE:

With a parallel connection of resistive and the inductive load switch on supply and vary the inductive load to have a power factor of 0.8 while noting I_T, I_L & I_R.
Then switch on capacitor & increase value to have unity p.f. Then note I_T, I_L, I_R & I_C.
Repeat process.

DISADVANTAGE OF LOW P.F.

1. Large KVA rating of machine
2. Greater Conductor Size.
3. High Copper loss.
4. Poor Voltage regulation

PRECAUTIONS:

Take readings of power factor when selector switch is at individual position.
Take readings without parallex error.

RESULT:

Power Factor of an inductive load was improved with the usage of a shunt capacitance.

CALCULATIONS:

1. $\cos\theta_1 = 0.8$, $\theta_1 = \cos^{-1}(0.8)$

$\Rightarrow \theta_1 = 36.86$

$\therefore Q_1 = VI_T \sin\theta_1 = 230 \times 1.4 \times \sin 36.86$

$\Rightarrow Q_1 = 189.98$

Also $\cos\theta_2 = 0.98$, $\theta_2 = \cos^{-1}(0.98)$

$\Rightarrow \theta_2 = 11.47$

$\therefore Q_2 = 230 \times 1 \times \sin 11.47 = 45.54$

Hence $Q = Q_1 - Q_2 = 189.98 - 45.54 = 144.44$ VAR

2. $\theta_1 = 41.40$ $\therefore Q_1 = 166.98$, $\theta_2 = 18.19$

$\therefore Q_2 = 78.43$

Hence $Q = 166.98 - 78.43 = 88.55$ VAR

3. $\theta_1 = 40.53$ $\therefore Q_1 = 571.12$, $\theta_2 = 18.19$

$\therefore Q_2 = 144.14$

Hence $Q = 571.12 - 144.14 = 426.98$ VAR

4. $\theta_1 = 44.76$ $\therefore Q_1 = 625.66$, $\theta_2 = 18.19$

$\therefore Q_2 = 176.84$

Hence $Q = 625.66 - 176.84 = 448.82$ VAR

Expt. No.

OBSERVATION TABLE:

SL.	VOLTAGE	P.F.	I_R	I_L	I_T
1.	230v	0.8	0.8	0.5	1.4
2.	230v	0.75	0.8	1	1.1
3.	220v	0.76	1.9	2.2	4
4.	218v	0.71	2	2.6	4.1

— WITHOUT COMPENSATION

SL.	VOLTAGE	P.F.	I_R	I_L	I_T	I_c
1.	230v	0.98	0.6	0.5	1	0.4
2.	230v	0.95	0.8	1	1.1	0.9
3.	220v	0.95	1.7	2.8	2.1	2.9
4.	218v	0.95	1.8	2.8	2.6	2.8

— WITH COMPENSATION

Teacher's Signature ....

Experiment - 7

AIM - To plot the IDMT characteristics of OC Relay.

APPARATUS REQUIRED - MC based OC relay Kit.

CONNECTION PROCEDURE -
Connect current Source output terminals C1A to C1 relay terminal & C2A to C2.

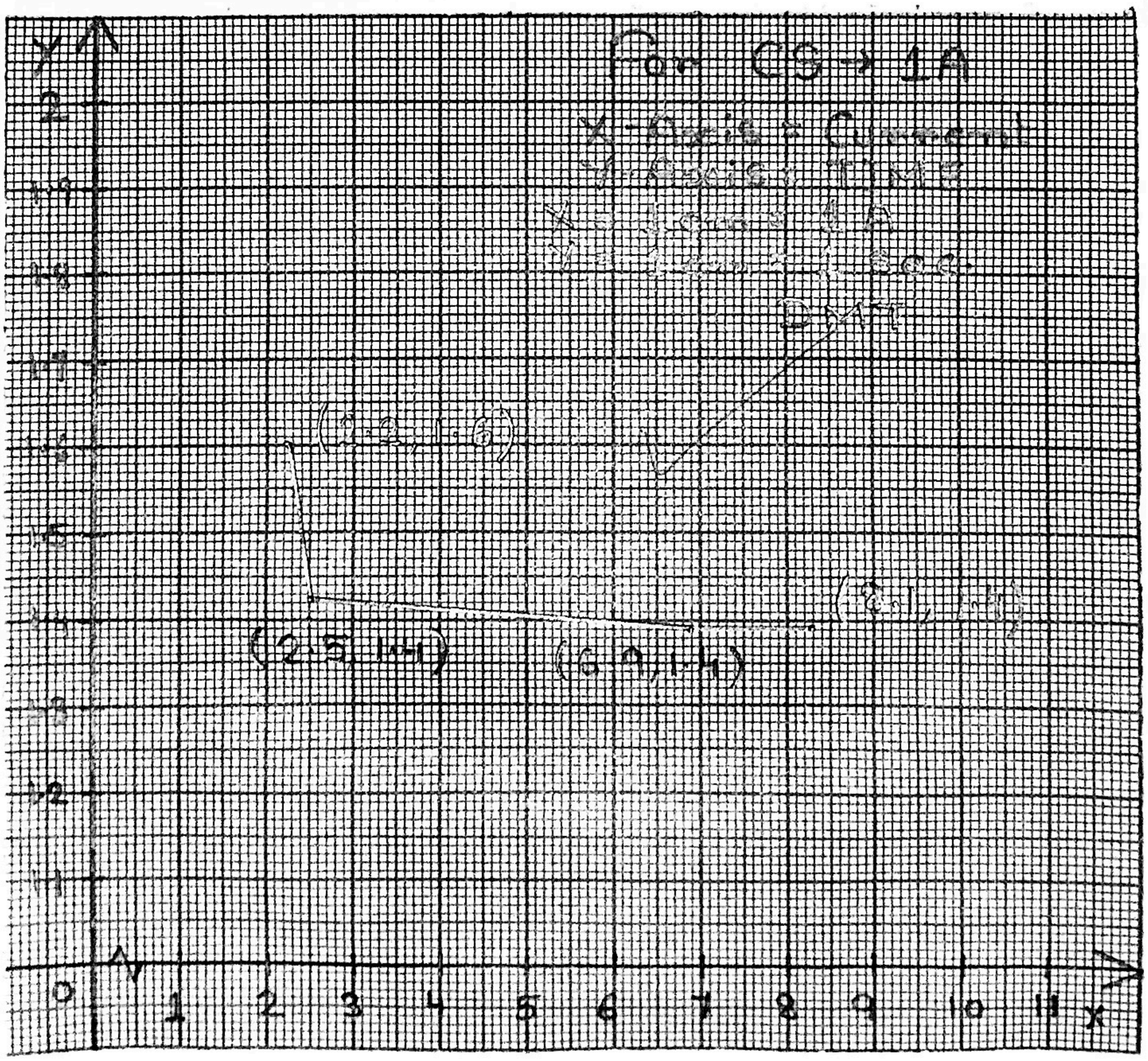
PROCEDURE -
Switch on power and set relay parameters.
In relay set current value as 1A.
Switch on MCB and press START.
Apply some current by adjusting autotransformer
Now fault current of 2A is set.
Press STOP manually & then START.
The relay trips after some time & stop clock indicates relay trip time.
Repeat procedure.

PRECAUTIONS -
Keep Auto-Transformer in minimum position and MCB when starting experiment.

DMT

SL.	CURRENT	TIME
1.	2.25 A	1.6 s
2.	2.58 A	1.43 s
3.	6.93 A	1.39 s
4.	5.50 A	1.90 s
5.	8.18 A	1.40 s
6.	9.67 A	1.56 s
7.	10.74 A	1.50 s

FOR:
CURRENT SETTING
= 1A



Expt. No.

OBSERVATION TABLE-

SL.	CURRENT	TIME	
1.	2.13 A	9.98 s	IDMT
2.	5.5 A	4.61 s	FOR:
3.	7.81 A	4.53 s	CURRENT
4.	8.90 A	4.52 s	SETTING
5.	11.10 A	3.38 s	= 1A

SL.	CURRENT	TIME	
1.	3.35 A	16.03 s	FOR:
2.	2.98 A	17.44 s	CURRENT
3.	3.51 A	9.45 s	SETTING
4.	4.88 A	6.98 s	= 1.5 A

SL.	CURRENT	TIME	
1.	3.10 A	29.99 s	FOR:
2.	3.16 A	17.41 s	CURRENT
3.	3.44 A	13.10 s	SETTING
4.	4.95 A	8.23 s	= 2A

Teacher's Signature ....

Experiment - 8

AIM - Measurement of ABCD constants of a transmission line using transmission line kit.

APPARATUS -

Transmission line model Kit
Variac (0 - 250 v)
Ammeter (0 - 2.5 A / 5A)
Voltmeter (0 - 200 v AC)
AC Ammeter (0 - 10 A)
Connecting Wires

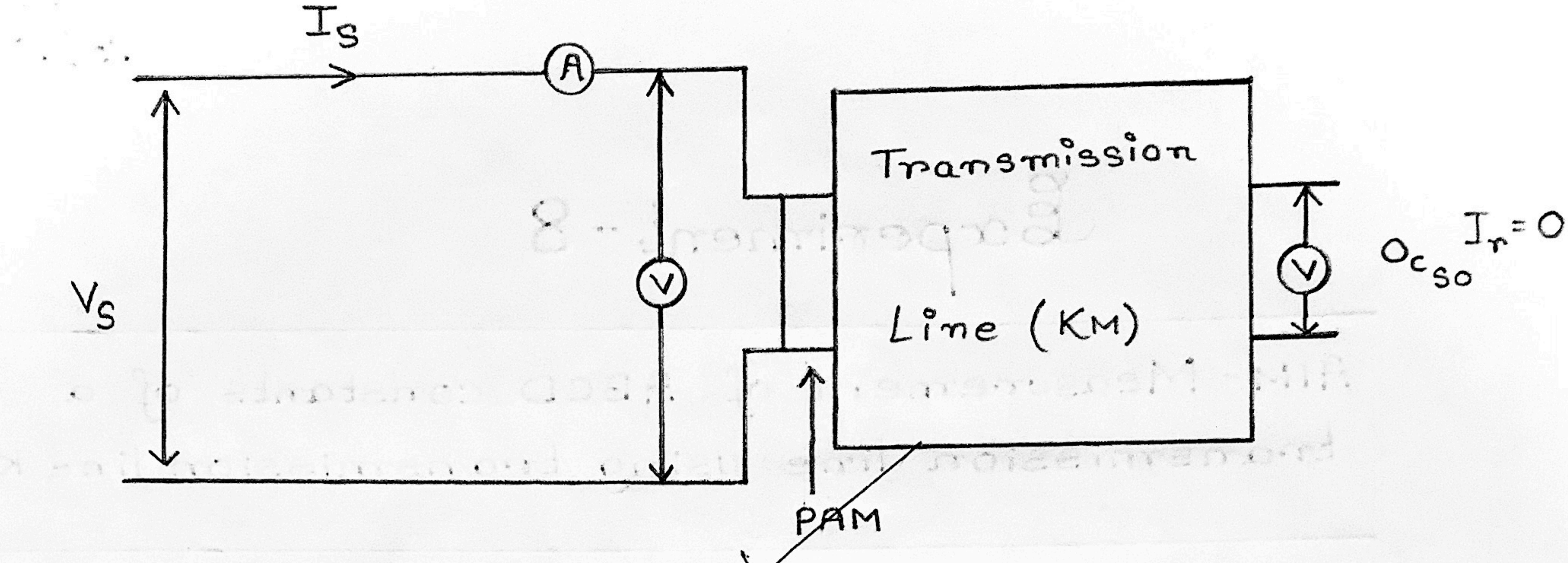
OBJECTIVE -

Model 600 KM transmission line with nominal T and π model & perform open-circuit & short circuit test from both ends & calculate ABCD parameters.

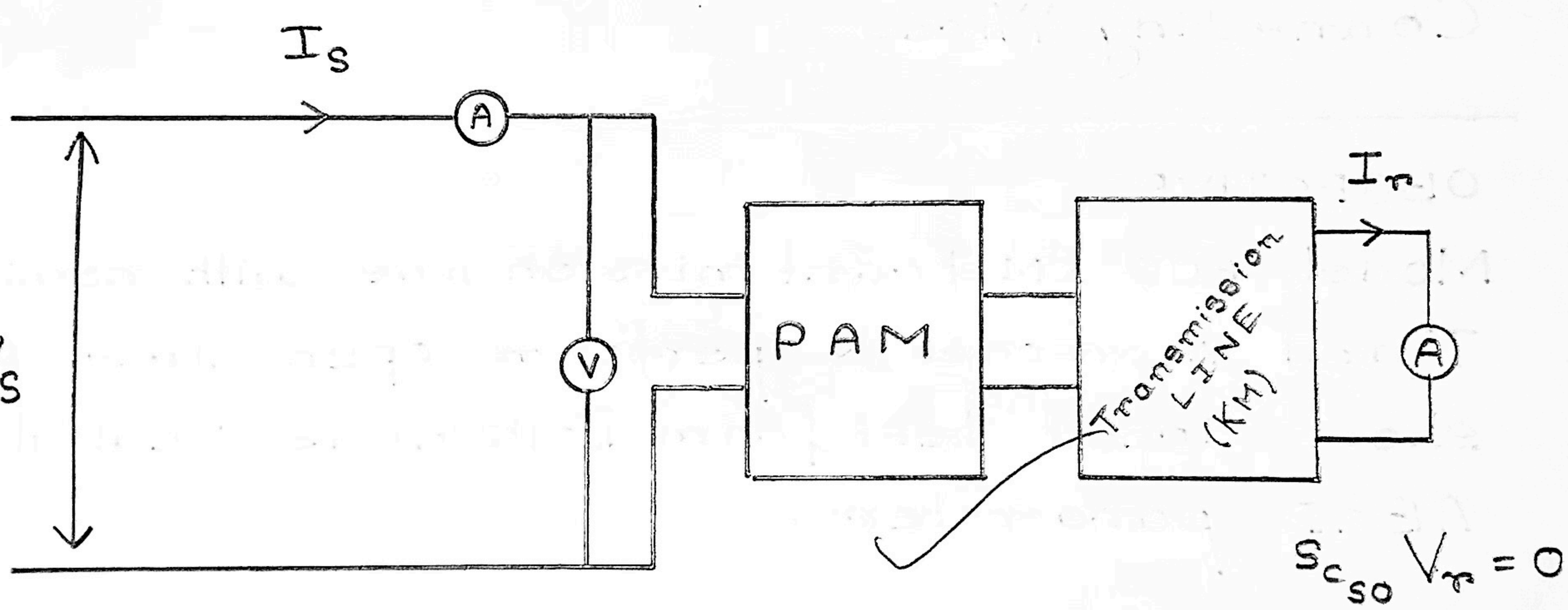
THEORY -

In a transmission line sending & recieving end voltage is rated by:

$$V_S = AV_r + BI_r$$
$$I_S = CV_r + DI_r$$



OPEN-CIRCUIT
DIAGRAM



SHORT-CIRCUIT
DIAGRAM

Similarly-

$$V_r = DV_s - BI_s = AV_s - BI_s$$
$$I_r = -CV_s + DI_s = -CV_s + AI_s$$

With $AD - BC = 1$ & $A = D$

The constants can be measured by an open circuit cum short circuit test at the end of lines.

For O.C. test on receiving end:

$$I_r = 0$$
$$V_{so} = AV_{ro}$$
$$I_{so} = CV_{ro} \quad \text{or} \quad Z_{so} = V_{so}/I_{so} = A/C$$

For S.C. test on receiving end:

$$V_r = 0$$
$$V_{sc} = BI_{rsc}$$
$$I_{sc} = DI_{rsc} \quad \text{or} \quad Z_{sc} = V_{sc}/I_{sc} = B/D$$

If the supply is provided on recieving end-

$$V_r = DV_s + BI_s$$
$$-I_r = -CV_s + AI_s$$

Now,

For O.C. test on sending end:

$$I_s = 0$$

$$V_{ro} = AV_{so}$$

$$-I_{ro} = -CV_{so} \quad \text{or} \quad Z_{ro} = D/C$$

For S.C. test on sending end:

$$V_s = 0$$

$$V_{rc} = BI_{sc}$$

$$I_{rc} = DI_{sc} \quad \text{or} \quad Z_{sc} = B/A$$

For ABCD parameters:

$$Z_{ro} - Z_{rc} = D/C - B/A = AD - BC / AC$$

$$= 1/AC$$

$$Z_{so} / Z_{ro} - Z_{rc} = A/C \times 1/1/AC = A^2$$

$$\text{or,} \quad A = \sqrt{Z_{so}/Z_{ro} - Z_{rc}} = D$$

$$B = AZ_{rc} \quad \& \quad C = A/Z_{so}$$

PROCEDURE:

1. Connect the units in either T or π model.
2. Connect source 'S' to point A.
3. Switch 'ON' supply.
4. Gradually increase voltage until 0 v.
5. Perform SC/OC test accordingly.

OBSERVATION TABLE:

SHORT CIRCUIT;

SL.	SE Volt.	SE Current	RE Volt.	RE Current
1.	30 v	2A	0 v	0.9 A

OPEN CIRCUIT;

SL.	SE Volt.	SE Current	RE Volt.	RE Current
1.	20 v	1.3 A	38 v	0 A

CALCULATIONS:

$V_S = AV_R + BI_R$

$I_S = CV_R + DI_R$

For open circuit where $I_R = 0$;

$V_S = AV_r \Rightarrow A = V_S/V_R = 20/38 = 0.526$

$I_S = CV_R \Rightarrow C = I_S/V_R = 1.3/3.8 = 0.342$

For short circuit where $V_R = 0$;

$V_S = BI_R \Rightarrow B = V_S/I_R = 30/0.9 = 33.333$

$I_S = DI_R \Rightarrow D = I_S/I_R = 2/0.9 = 2.222$

Hence :

$A = 0.526\ \Omega$

$B = 33.33\ \mho$

$C = 0.342\ \Omega$

$D = 2.22\ \mho$

ABCD parameters of Transmission Lines showing the Ferranti Effect.

RESULTS :

ABCD parameters were obtained from data.

Experiment - 9

AIM - To study the measurements of a differential protection of a transformer.

APPARATUS - Trainer Kit

FORMULAS :

I_1 = Primary Current

I_2 = Secondary Current

$\therefore \; I_d = I_1 - I_2$

$I_r = I_1 + I_2 / 2$

$DF_1 = 0.4$ pu , $i_K = 0.2$ pu , $K_p = 1$ pu

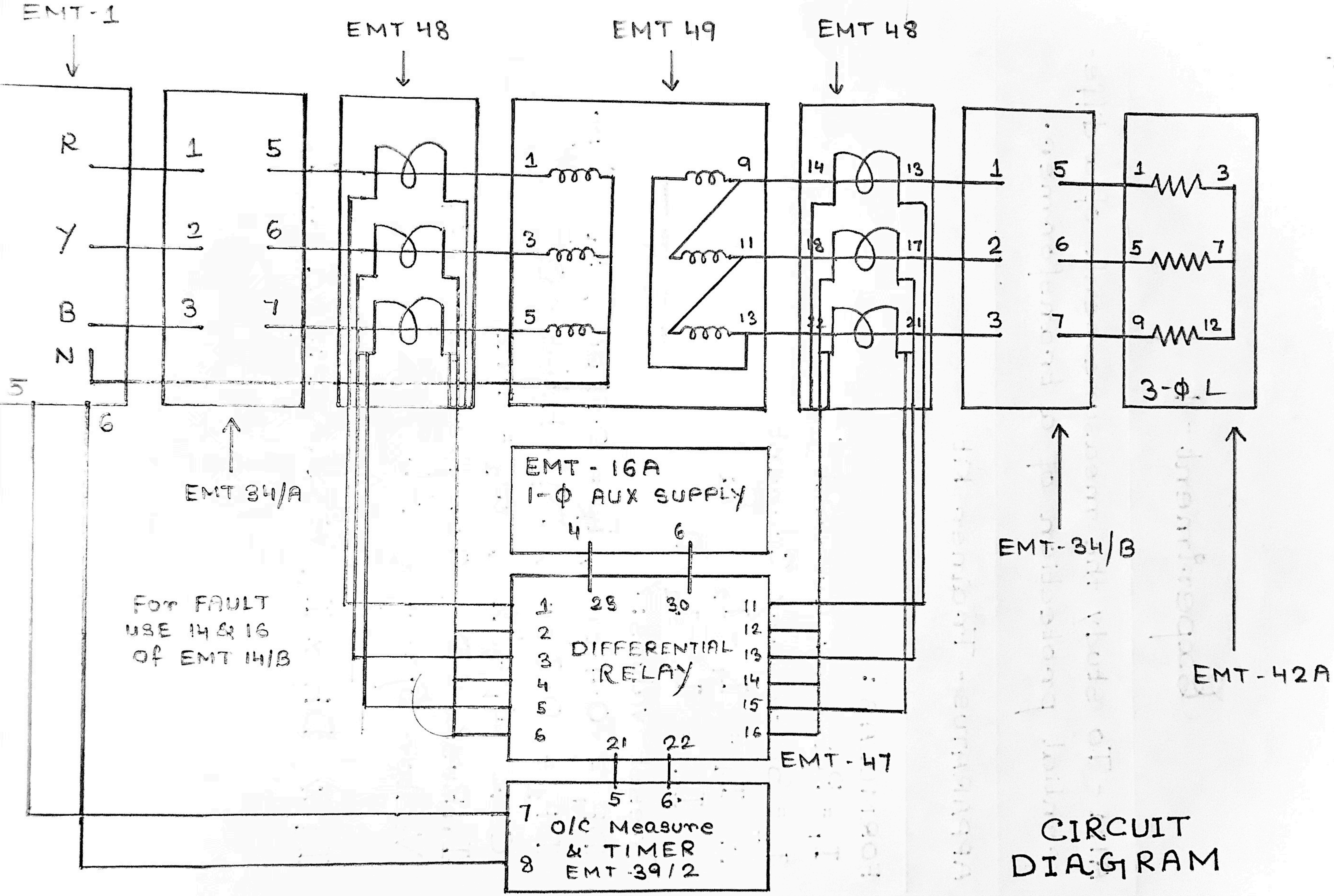
$DF_2 = 0.8$ pu , Diff. HiSet = 0

CTR $\omega_1 = 2$, $\omega_2 = 1.12$

InRush = 0 , Over Excitation (5f) = 0

Vector Group = Yd_1

$$I_d \geq DF_1 \times I_r + (1 - DF_1/2) \times I_K$$



CIRCUIT DIAGRAM

PROCEDURE:

1. Make wiring sequence and observe table.
2. We are using 3-ϕ Numeric relay R, Y and B.
3. Keep load selection switch on EMT-42A at 125 Ω and on EMT-14B at OFF position.
4. Keep bypass switch on EMT-39 panel open.
5. Switch on AC supply by turning 4A MCB ON.
6. Press start push buttons PB1 on EMT 39 first & then on EMT 1 to switch on protection circuit.
7. If TRIP LED is on then press & hold reset push button for 3-5 sec otherwise ignore.
8. Now close bypass switch on EMT-39.
9. To create a fault on LL on primary side connect resistor on EMT 14B to transformer primary between R & Y phases, Keeping the resistance selection switch on EMT 14B OFF.
10. Put resistor selector switch on EMT 14B at 750 Ω. Note down values from display.

Now, again:

11. Press RESET button on relay panel.
12. To create a LN fault on primary side, connect resistor from EMT 14B between R & N of primary transformer EMT 49.
13. Press START push buttons on EMT 39 & EMT 1 to switch on protection circuit.

14. Put resistor selector switch on EMT 14B at 750 Ω & then at 300 Ω and note down.
15. Press RESET button & repeat for LL fault on secondary side and with resistor Switch at 750 Ω, 600 Ω & 300 Ω. Note it.
16. Always note down resistance value from EMT 14B, current of primary (I_p) and Secondary (I_s) from display panel.
17. Press RESET button & repeat for LL fault at primary, secondary by connecting a resistor from EMT 14B to secondary side of transformer EMT 49 between R-Y phase.
18. Push start PB1 on EMT 39 & EMT 1.
19. Put resistor selector switch on EMT 14B at 750 Ω, 600 Ω, 300 Ω, 212 Ω & 162 Ω.
20. Note readings & press RESET.

CONCLUSION:

From the above experiment it is observed that for any in-zone faults like LL, LG, LN whether primary or secondary the relay will trip.

OBSERVATION TABLE:

SL	FAULT	Short R.	I_p	I_s	I_d
1.	L-L (primary)	750	52	21	31
2.	L-N (primary)	212	49	19	30
3.	L-L (secondary)	212	51	20	31

CALCULATIONS:

1. $I_1 = 52$, $I_2 = 21$, $I_d = 31$, $I_r = 0.36$ pu
$= 0.52$ pu $= 0.21$ pu $= 0.31$ pu
$DF_1 = 0.4$ pu, $i_K = 0.2$ pu, $k_p = 1$ pu
$I_d \geq DF_1 \times I_r + (1 - DF_1/2) \times i_K$
$\therefore 0.31 \geq 0.30$

2. $I_1 = 0.49$ pu, $I_2 = 0.19$ pu, $I_d = 0.30$ pu, $K_p = 1$
$\therefore I_d \geq DF_1 \times I_r + (1 - DF_1/2) \times i_K$
$\therefore 0.30 \geq 0.296$

3. $I_1 = 0.51$ pu, $I_2 = 0.20$ pu, $I_d = 0.31$ pu
$\therefore I_d \geq DF_1 \times I_r + (1 - DF_1/2) \times i_K$
$\therefore 0.31 \geq 0.3$